TITLE: Short Range Reconnaissance: The LUNA Experimental UAV Program

Short Range Reconnaissance
The LUNA Experimental UAV Program

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1. SUMMARY

This paper reports on the background, the performance requirements, technical characteristics, special program features and lessons learned from the LUNA Experimental UAV Program.
This program is being funded by the R&D Program of the Bundeswehr. This 18 month effort will be finalized by phase 2 field trials in may/june 1999. Main goals to be proven are, reconnaissance performance in an operational environment and easy handling i.e. mission planning, mission conduct and maintenance.
The lessons learned from LUNA so far can be applied to other programs - already today, but also particularly in the future.

2. Introduction

LUNA is an acronym and stands for "Luftgestützte unbemannte Nahaufklärungsausstattung", which means in English "Airborne Unmanned Close Range Reconnaissance System". LUNA is a pure pre-phase activity and originates from an initiative of the Armored Reconnaissance Corps from the year 1990. The basic idea was to equip the armored reconnaissance units beyond the FLOT with an airborne means of reconnaissance that is easy to operate. This should both improve the self-protection capability and increase the units' effectiveness.
In 1996, the BWB conducted an international competition in which eight competitors from different countries presented their solutions. The selection of the contractor had been based on a careful assessment in accordance with recognized standards.
The study contract for the development and testing of the LUNA X-2000 functional model was signed on 10 October 1997 with the Contractor EMT. After 18 months this contract is now about to expire. In about 2 to 3 months it will be completed with phase 2 of the field tests.

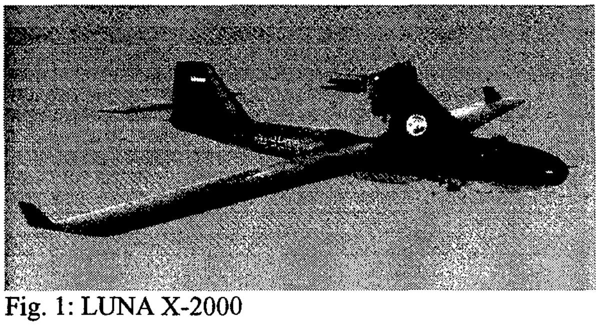

Fig. 1: LUNA X-2000

So far, four aerial vehicles have been built and certified for military use under this R&D contract.

3. Performance Requirements

The system requirements were already defined in such detail that due to their nature and content they largely fulfilled the requirements of a development specification.

The LUNA requirements specification stipulated the following targets:

- use of commercial-off-the-shelf components, where possible,
- takeoff weight approximately 20 kg,
- minimum operating range of 10 km,
  minimum data link range of 20 km,
- very simple operation, automatic flight control; operation by two persons, aeronaticall skills not required,
- real-time E/O and IR images via data link,
- detection, recognition, identification and location of individual wheeled and tracked vehicles,

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even if equipped with signature-reducing camouflage, by day and night and in bad weather,
- integration/transport in the rear hold of an armored reconnaissance vehicle or small road vehicle.

4. Technical Characteristics

In summary one can say that the original program expectations for LUNA X-2000 were far exceeded in terms of schedule and technology.

4.1. Takeoff and Landing

Investigations to determine the optimum launch and recovery procedure led to the design of a foldable bungee catapult. It takes a 4 meters rail to accelerate the UAV to about 70 km/h, well beyond liftoff speed. For landing, a special parachute is being used. The released parachute turns the airframe over in a backwards position in order to protect the payload. The sink rate is about 4 m/s. The touchdown is dampened by mechanical shock absorbers due to the high elasticity of the airframe.

4.1. Airframe, Propulsion, Signatures

The required takeoff weight, payload and endurance could only be achieved by a very economic use of propulsion power.
The aerial vehicle was therefore designed as a high-performance powered glider.
It has a maximum speed of 160 km/h; at cruising speed, i.e. 70 km/h, it only needs 0.75 kW of its nominal propulsion power of approximately 6 kW.

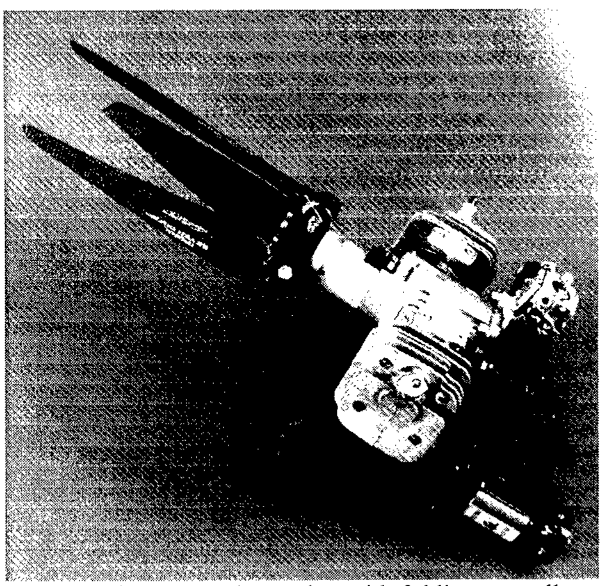
Fig. 2: 2-piston 2 stroke engine with folding propeller

This is less than the thermal power loss of other tactical drone systems and, of course, results in considerably better signature characteristics.

The engine can be randomly switched off and restarted during flight.
In unpowered mode the LUNA X-2000 has a glide ratio of 1:18; over a distance of 18 km the vehicle loses about 1000 m in altitude.
The resulting operational advantages will have to be investigated in detail yet.

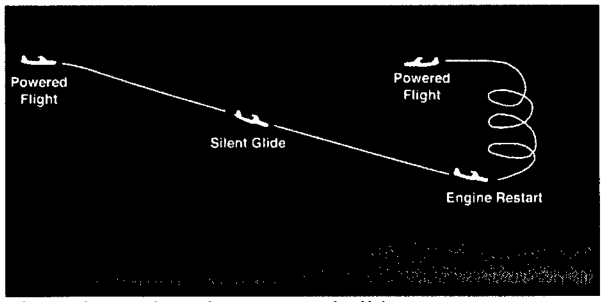

Fig. 3: intermittend unpowered glide

The endurance time in the target area can presumably be doubled, and the acoustic and IR signatures will be further improved.
Due to the fiber glass design, additional measures to reduce the LUNA X-2000 radar signature will not be necessary. It can be assumed that the contracted laboratory measurements will yield a value that meets the requirements for a larger drone with stealth characteristics.

4.2. Sensors

Undoubtedly, the central aspect is the reconnaissance performance of the system.
LUNA X-2000 is among the top players and can compare with any other system.

The miniaturized sensor module with its weight of about 2.1 kg currently contains an analog daylight color video zoom camera and a digital thermal imaging camera. Alternatively, each one of these cameras can be coupled with a digital still image camera with internal image storage. The payload is installed in a gimbal system and can be continuously tilted by 45° in any direction from the ground control station.

With its multiple sensors LUNA X-2000 meets the requirement for detecting, recognizing, locating and unambiguously identifying individual tracked or wheeled vehicles (up to 0.5 tons).
At the moment and in the foreseeable future, no other airborne reconnaissance system comparable in size and takeoff weight can fulfill these requirements.

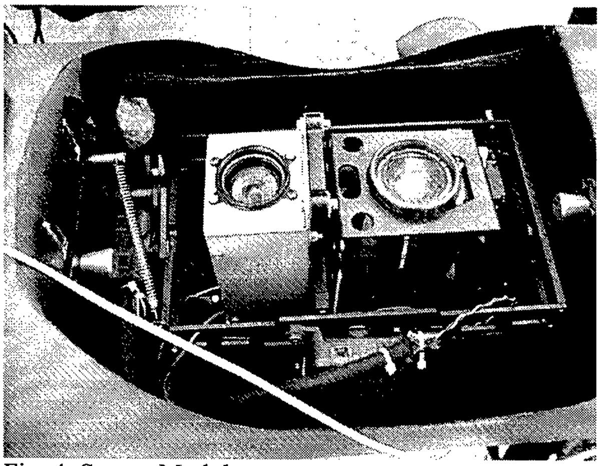

Fig. 4: Sensor Module

In addition, the drone is equipped with a nose mounted color video camera which provides the operator with a permanent view of the airspace along the flight path (clouds/weather) and of the reconnaissance area lying ahead.

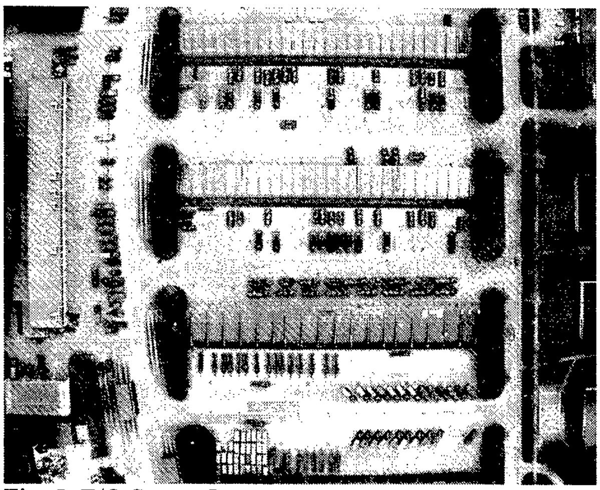

Fig. 5: E/O Sensor Image

4.3. Data Link

For real-time transmission of the sensor data collected the LUNA X-2000 system uses a microwave data link in the 4.4 to 5.0 GHz carrier frequency band which is rather beneficial in terms of atmospheric attenuation.

Two modes are available, 5 MHz bandwidth analog and 10.7 Mbit/s digital.

In order to improve the interference resistance of the radio relay link, both modes use data scrambling. In digital mode a continuous 8 bit checksum check and frequency hopping are performed.

On radio contact loss an automatic re-contacting procedure is being pursued.

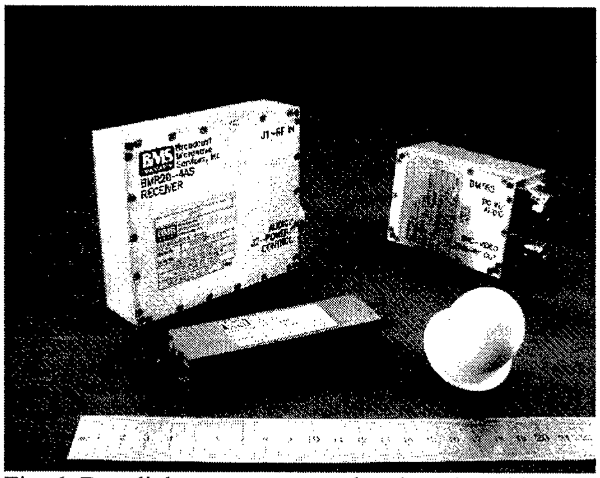

Fig. 6: Data link components and on board tracking Antenna

The data link is equipped with a power management; maximum antenna output is 3 Watt. For the time being a datalink range of 22 km has been demonstrated. During the concluding 2nd phase of the field tests in May/June this year, EMT will employ an improved data link with a range of 65 km which has been adapted to the LUNA X-2000.

Successful ground tests were already performed by the U.S. supplier, the hardware has been ordered and delivery is in process.

4.4. Flight Control System (FCS)

The LUNA X-2000 flight control system is miniaturized and fully digitized. Its capabilities and performance are equal to those of manned aircraft.

The on-board equipment comprises an attitude gyro, a magnetic compass, rate of turn sensors, air data sensors and accelerometers.

Basic navigation is supported by SATCOM differential GPS. Up to a distance of 20 km from a reference station (usually the ground control station) this provides for navigation and detection accuracies with a remarkable CEP of about 10 m.

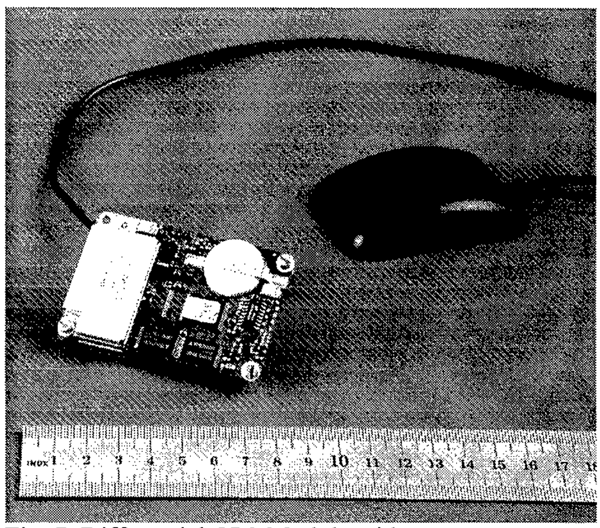

Fig. 7: Differential GPS Module with Antenna

4.5. Man-Machine Interface

In consultation with the purchaser and the user, the human engineering concept for the LUNA X-2000 operation was repeatedly streamlined in several iterative steps to integrate automatic processes.
By now the device is extremely easy to handle. The System can be operated by 2 persons. Turn around time is less than 15 minutes. As a matter of fact, armored reconnaissance corps soldiers without any special training were able to effectively operate the system after only a few hours of familiarization.

4.6. Ground Control Station

The ground control station is equipped with two screens, one for the aerial and video images taken, the second one for displaying a map with the flight path and a IFR-type virtual cockpit. The map presentations are based on the Bundeswehr standard digital 3-D maps of the Bundeswehr Geographic Office; that is an essential element of mission planning. The 3-dimensinal digital map shows the air vehicle position, the camera footprint and flight path. To facilitate image interpretation and operator orientation, the images are north referenced in real time.

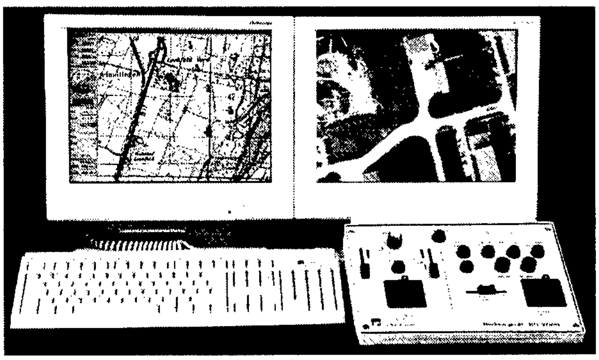

Fig. 8: Ground Contol Station

4.7. Mission Planning

Mission planning is performed within a few minutes by mouse or keyboard entry of a list of waypoints. The mission planning software checks the data entered for plausibility and feasibility, particularly with respect to obstacle avoidance, shading and range. The software issues error warnings and proposes corrections. The fully automatic mission – from launch to automatic recovery – is preprogrammed by a sequence of waypoints. The anticipated landing position does not necessarily have to identical with the takeoff position. It is possible to transmit sensor data to another ground control station and to transfer control of the aerial vehicle to another station.
For post-flight analyses and for training purposes the systrem allows complete mission playback including sensor data, map display and virtual cockpit.

4.8. Special Program Features

- Already at contract conclusion, the parties to the contract were aware of the fact that a dual-use product would be developed. The company had to aim at producing a marketable and competitive product. This requirement was met by EMT. Using own resources, they realized improvements beyond their contractual obligations.

- The contractor successfully managed to implement the capabilities required from this unmanned reconnaissance system with a minimum effort. The scope of the system was consistently kept small. This results in a reduced complexity and, of course, cost savings for future procurement and use.

- The Bundeswehr material development cycle calls for the use of commercial-off-the-shelf materiel and readily available components as a standard solution. New developments shall be the exception to the rule. Therefore, COTS materiel and components were used, wherever possible. To avoid making compromises, however, only such COTS parts were selected which proved to be absolutely suitable due to their function, performance, reliability, price, availability, and competitiveness.
Due to the consistent use of sophisticated commercial materiel and components the time required up to the functional model tests was extremely short.

- No major technical problems arose during the life of the contract. Since contract conclusion approximately 18 months ago about 90 flights have been performed - under icing conditions, with flight altitudes above 3000 m, under bad weather conditions, and with up to 5 flights per day with only one vehicle. The statistics show a technical availability of more than 98 %, no equipment losses, and no damage that would have required third or fourth echelon maintenance actions. These results are unmatched in the field of UAVs, at least as far as the Bundeswehr is concerned.

- As of today, the system can already be considered to be marketable and commercial. It has been granted a preliminary certification a category 2 certification for flights over thinly populated area is envisaged by the Bundeswehr authorities.
The certification of functional readiness and operational safety has been required by the Intelligence and Reconnaissance Study Group it should be issued timely to phase 2 field trials.

5. Summary and lessons learned

Small system size, performance, reliability, ease of handling, procurement and life cycle costs make LUNA X-2000 to fit the acutal Bundeswehr needs.

Based on the degree of maturity achieved within that 18 month contract, from today's technical and contractual point it is considered possible to have the first operable system delivered in a 6-8 months timeframe.

Competition is most valuable to increase contractor performance and to decrease costs in government funded R&D programs.

Extended implementation of 1st choice COTS items is considered a key element to reduce the overall development risk to cut program costs and to concentrate resources on areas of high interest.

Teamwork and ingenuity seam to be more beneficial to the success of a program than outsourcing and shareholder value.